tographs. It is thought that the whirling motion is apparent. A fluid color screen and Seed plate were used. Rain had fallen in the twelve hours preceding the time of photographing this cloud at San Francisco and generally throughout California. In the clearing weather which temporarily followed heavy frost occurred. One hour previous to the time of taking these photographs the sky was free of clouds, excepting a few alto-strati passing from northwest to southeast. The wind was north, the pressure rising rapidly (0.08 in two hours), and in the valleys back of San Francisco the skies were clear. Clouds, mostly of the cumulus formation, were in sight. Two hundred and fifty miles south of San Francisco rain was falling; temperature 42°, and farther south it was even colder.

Two hours after taking the photographs the sky at San Francisco was again cloudy, the barometer falling rapidly, and rain reported 15 miles to the north. In the San Joaquin Valley at this time heavy cumulus clouds were moving rapidly from the northwest. Through southern California and Arizona it was overcast and raining. Five hours later there had been light rain at San Francisco, snow in Nevada, and dense cumulus clouds resting on the mountains, rain falling generally in California, and strong westerly winds in southern California. Killing frosts were reported generally in California at the next morning's observations after these photographs were taken.

## THE PROBLEM OF THE KITE.[1]

By Mr. ALEXANDER G. MCADIE, Local Forecast Official (dated December, 1896).

There are two general classes of bodies which traverse or navigate the air; first, there are those which float or soar, without any apparent expenditure of energy; and second, those which swim or force a way through the atmosphere. Flying machines, birds when using their wings, and all aerodromes or air runners belong to the second class, expending energy in their flight. Balloons when drifting, kites, aeroplanes, and soaring birds belong to the first class. It is therefore, with the kite, as an inert body wholly immersed in air, and not rising or falling because of any acquired or inherent energy of its own that we shall have to deal, in this paper. Indeed, the more general way of treating this subject is to consider the kite as a disturbing factor in air motion. The atmosphere is a mechanical mixture of certain gases. As a whole, it is subject to certain forces and is in motion. Into this fluid, with all its varying stresses, we introduce a disturbing mobile plane. We are to investigate the forces acting in the vicinity of this plane surface. We shall have to consider the pressure of the wind upon both kite and kite line at every point, the restraining pull of the kite line, the attraction of gravity upon kite and line, the peculiar resultant forces which sometimes make a kite with a given initial velocity rise apparently without wind pressure and in opposition to gravity, and, finally, the friction of the air upon the kite surface. The form of the surface exposed must be discussed and the relative value of different presentations of area to wind, whether steady or gusty, given. Almost all the kites in popular use to-day have plane and regular surfaces. We have the plane malay kites and modifications, combination planes with dihedral angles, and cellular or Hargrave kites. Curved areas have not yet come into general use, although unquestionably possessing certain advantages.

Our mobile body, whatever its form may be, is introduced into air either when the flow is continuous, the so-called steady wind, or when the flow is intermittent, the energy being spent in variable pulses. Indeed the problem of the kite may be likened to that of a plane free to move in every direction, immersed in a reservoir of flowing water which is further disturbed by a number of dashers out of step. Aside from the difference in specific gravity, the plane will have an upward motion due to the component of steady flow and the effect of the countercurrent. It is, perhaps, well to emphasize the fact that a plane or a kite will worm its way upward when the inclination of the axis changes responsively to aerial puffs and pulsations. (See Professor. Langley's two memoirs, viz, Experiments in Aerodynamics, and, The Internal Work of the Wind).

Everyone who has flown kites is familiar with the fact that it is easier to get the kites into the upper air when the lower air comes in rapid puffs than when the air moves uniformly, the velocity, as indicated by a Robinson anemometer, being the same in both cases. An anemo-cinemograph would have given us a record whence the relative gustiness (for want of a better term) could have been shown. It is well known that the Robinson anemometer smooths out this factor. As an illustration of the fact that a kite can be raised higher in what appears to be a wind of less velocity, we cite the case of some kites flown on August 20, 1896. At about 11 a. m. the velocity of the wind was 12 miles per hour at the surface, and the kites were decidedly higher than at 3 p. m., when the wind at the surface was 16 miles per hour. It must also be pointed out that one of the great advantages of flying kites in tandem arises from the changed inclination of the wind to the planes. An example will, perhaps, bring this out more plainly.

On August 28, 1896, two cellular kites were flown in tandem at ———. The following table gives the principal data obtained:

| Length of kite wire. | | Angle. | Elevation. | | Changes. | |
|---|---|---|---|---|---|---|
| Feet. | Meters. | | Feet. | Meters. | Length. | Height. |
| | | ° ′ | | | *Meters.* | *Meters.* |
| 6,656 | 1,998 | 32 45 | 3,640 | 1,109 | ........ | ........ |
| 6,021 | 1,835 | 35 | 3,450 | 1,052 | —163 | —57 |
| 5,640 | 1,719 | 39 30 | 3,550 | 1,082 | —116 | +30 |
| 5,190 | 1,582 | 44 | 3,600 | 1,097 | —137 | +15 |
| 4,623 | 1,409 | 48 | 3,450 | 1,082 | —173 | —15 |
| 4,114 | 1,253 | 54 | 3,300 | 1,006 | —156 | —76 |
| 3,860 | 1,176 | 57 | 3,230 | 984 | — 74 | —22 |
| 3,882 | 1,122 | 59 | 3,185 | 970 | — 54 | —14 |

From the above it appears that while the line was being pulled in evenly the kite descended 57 meters for the first 163 meters of line, or fell nearly 1 meter for every 3 meters of line. But 500 feet lower in the air we get a fall of 14 meters for 54 meters of line. But note that after the first fall the kite, owing to the pull along the line, gains in elevation, and this gain was probably independent of any change in wind direction and velocity, although, as we shall see further on, the lower kites did indicate wind currents different from those above. The experiment is of course imperfect, in that we were not able to measure the wind pressure at the different altitudes. The wind velocity at the ground at the time the highest elevation was made (4:10 p. m.) showed no appreciable change.

The first of the forces acting in kite work is the *tension* of the string or line, or, as it is generally called, the *pull*. And we see in the above illustration how increasing the tension along the line results in an increased elevation, provided the pressure of the wind on the surface of the kite and the force

[1] In accordance with the policy of publishing the views of all who have written on the theory of the kite, the Editor, in the last number of the MONTHLY WEATHER REVIEW, presented a rather lengthy memoir by Prof. C. F. Marvin. In continuation of the same subject he submits the following extracts from a memoir by Mr. Alexander G. McAdie. As Mr. McAdie's memoir embraced other matters than the strictly mechanical theory, these extracts may seem disconnected but they are believed to express fully the views presented by him.

of gravity on the mass are not thrown too much out of equilibrium. In the effort to restore equilibrium, the kite moves, and if the forces are properly balanced the motion will be upward. The resultant effect of the wind pressure and gravity is balanced against the line tension. We have even seen how, by increasing the tension and shortening the line, a greater elevation was reached. * * * Roughly speaking, there are four conditions in the balancing of the tension and resultant: First, where the two are equal and the inclination of the resultant force to the normal is exactly 180° different from that of the tension; second, assuming constant kite areas, the resultant may yet change in inclination; third, the inclination of the line may be changed; and, finally, both tension and resultant may change.

On September 14, 1896, three large cellular kites were flown. The weather was somewhat cloudy, and the electrification was so great that it was necessary to ground thoroughly the reel and wire. When the ground wire was removed for even so short a period as ten seconds, sparks one-quarter of an inch in length were obtained.

| Length of wire. | | Angle. | Elevation. | |
|---|---|---|---|---|
| Feet. | Meters. | | Feet. | Meters. |
| | | ° | | |
| 2,247 | 683 | 29 | 1,100 | 335 |
| 1.993 | 606 | 32 | 1,060 | 323 |
| 1,739 | 530 | 38 | 1,080 | 329 |
| 1,485 | 454 | 43 | 1,045 | 318 |
| 1,231 | 375 | 52 | 1,020 | 311 |
| 977 | 299 | 50 | 760 | 232 |
| 723 | 219 | 52 | 580 | 177 |

On September 19, 1896, cellular kites in tandem were flown with the following results:

| Length of wire. | | Angle. | Elevation. | |
|---|---|---|---|---|
| Feet. | Meters. | | Feet. | Meters. |
| | | ° | | |
| 7,516 | 2,291 | 33 | 4,100 | 1,250 |
| 6,316 | 1,925 | 35 | 3,630 | 1,106 |
| 5,452 | 1,661 | 36 | 3.210 | 978 |
| 4.465 | 1,361 | 39 | 2,825 | 861 |

At a height of 4,000 feet the uppermost kite repeatedly disappeared into a layer of cloud which covered nearly the whole sky. At other times it has been noticed when the sky was partially clouded that in the clear spaces the kites would drop a little, and on the other hand rise when just below or about to enter a bally cumulus cloud.

We are now ready to resolve the forces acting upon various types of kites beginning with the old hexagonal tailed kite. The customary rigging of this kite is well known. Stability was generally obtained by means of a long tail, which, if the kite were of large dimensions, was made of some weighty material. Occasionally when cloth was scarce, small stones and pieces of wood were tied to the tail. On one interesting occasion, the writer recalls sacrificing, at a well-known observatory, a pair of blue flannel trousers to make a tail for a kite, and if memory is correct the kite rose and remained in the air for some time. A tail may be of use in changing the effective area as well as changing the center of gravity. Thus Archibald has taken a malay kite, which after repeated trials had been abandoned as a non-flyer, and by adding little conical wind carriers in the form of tails, succeeded in sending the kite up. With the hexagonal kite we have a plane surface opposed to a given wind pressure, and depending for its elevation upon the balancing of the resultant wind pressure, the line tension, and the action of gravity on the kite and tail. If the kite is to rise, there must always be a balancing upward component force. Gravity is the one force whose action is constant. The resultant wind pressure is a variable quantity, and the problem with the hexagonal (as with every form of kite) is well stated by Marvin in his paper (MONTHLY WEATHER REVIEW, May 1896, p. 158): "To so arrange the surfaces and bridle of the kite that it can promptly, constantly, and easily accommodate itself to the innumerable and often very great and sudden changes which we find occurring in the force and direction of the wind." By bridle we mean point of suspension or point of application of the line tension which force necessarily results from the other forces. Neglecting skin friction, which may vary with the material used, the wind pressure is exerted upon the kite at various angles as the wind stream lines are seldom constant. A resultant wind pressure is found by combining (by the parallelogram of forces) the pressures for the different directions. The point of application of this mean resultant wind pressure gives the center of pressure of the kite. This is not a fixed point but one that moves with changes in the wind pressure.

The center of surface or center of effective area and the center of gravity are self-explanatory terms. In order that the forces acting upon a hexagonal kite may be in equilibrium, the product of the component mean pressure normal to the kite and the distance between the centers of pressure and area must equal the component of gravity multiplied by the distance between the bridle point and center of gravity. In order to resolve all the forces acting upon an ordinary kite, namely, wind pressure upon surface, tail, and string, line tension, and the downward pull due to gravity, we should have data covering wind pressure per unit of area, line tension continuously recorded, and the kite dimensions in detail. Unfortunately kite flyers have not generally taken note of these, although they may have noted at the time the weights of kite and tail, and the area exposed to wind. The wind velocity at the ground, in miles per hour, may also have been noted. The wind pressure aloft, however, is an indeterminate quantity until sensitive recording anemometers are devised suitable for use at different levels in the air. * * * At this point it may be well to emphasize the instability of the wind pressure. Too much can not be said about it, inasmuch as it is the prime factor in kite flying. In some anemometer comparisons made by Fergusson (see Blue Hill Meteorological Observations, 1896, p. 287) there is given a tracing from a pressure plate in which the record paper was moved with a speed of 20 inches a minute in order to separate individual gusts. "It is only fair," says Fergusson, "to suppose that some of the oscillations are due to vibrations of the plate and not of the wind (also true in the case of kites), but by far the greater part are real changes in wind pressure, *and in some cases there are ten or more in one second.*" * * * But the essential factor in determining the kite's elevation is the relative pressure upon the kite's area, as this area changes in inclination to the resultant mean wind. The pressure varies with different inclinations, and we saw at the beginning of this paper that it is possible for a kite to make altitude by rapid changes in the inclination

| Inclination. | Proportional pressure. | Inclination. | Proportional pressure. |
|---|---|---|---|
| ° | *Per cent.* | ° | *Per cent.* |
| 1 | 3.5 | 16 | 51.2 |
| 2 | 7.0 | 17 | 53.8 |
| 3 | 10.4 | 18 | 56.5 |
| 4 | 13.9 | 19 | 58.9 |
| 5 | 17.4 | 20 | 61.3 |
| 6 | 20.7 | 21 | 63.7 |
| 7 | 24.0 | 22 | 65.7 |
| 8 | 27.3 | 23 | 67.8 |
| 9 | 30.5 | 24 | 70.0 |
| 10 | 33.7 | 25 | 71.8 |
| 11 | 36.9 | 26 | 73.7 |
| 12 | 39.8 | 27 | 75.2 |
| 13 | 43.1 | 28 | 77.1 |
| 14 | 45.7 | 29 | 78.6 |
| 15 | 48.6 | 30 | 80.0 |

to the wind, even in light winds. Changes in the length and area of the tail, changes in the weight and proportions of the kite itself, changes in the bridle, all directly affect the centers of gravity and pressure of the whole system. When these are not in perfect equilibrium, diving results. To get the relative pressure upon inclined flat surfaces we have the accompanying table given by Chanute (Progress in Flying Machines) based upon Duchemin's formula.

Mr. A. M. Herring in his paper upon Dynamic Flight (The Aeronautical Annual) shows that the center of pressure, varying as it does with the inclination of the wind to the plane, must be constantly maintained above the center of weight of the kite if the kite is to fly, and in his judgment "the best solution is probably to be found in such surfaces and their arrangement relative to each other as will remain undisturbed by changes in the wind." * * * Mr. Herring says: "At almost all angles of inclination the center of pressure on a square plane is proportionately farther forward than is the center of pressure on a plane whose advancing edge is five times its breadth. Similarly, at slight angles, the center of pressure on a properly curved surface (whose vertical projection is square) is farther back than either. Another variation in the position of the center of pressure is that produced by speed. If a plane or slightly curved surface be held in a wind and be inclined at a very flat angle, its center of pressure will be found farther forward at high speed than at low." Again, Herring states that "the center of pressure on considerably curved surfaces undergoes a peculiar reversal in its position. For a surface in which the curvature is such that the rise of arc is about one-eighth the cord length, and where the highest point of curvature is one-third the way from the front, the maximum forward position of the center of pressure is found when the surface is tilted at about five degrees; it however travels rapidly backward for either a lesser or greater inclination of the cord."

## CLIMATE OF ALASKA.

By A. J. Henry, Chief of Division of Records and Meteorological Data.

The statistics of temperature of central and interior Alaska given below are of especial interest at the present time. The climate of the coast is comparatively well known chiefly through the compilation of Dr. William H. Dall, published in the Pacific Coast Pilot, Alaska, Appendix I, Meteorology and Bibliography, Washington, 1879.

The chain of coast stations in Alaska maintained by the Signal Service (now Weather Bureau) was extended up the Yukon in the fall of 1882, and a few fragmentary series of meteorological observations were maintained at the trading posts of the Alaska Commercial Company during the closed season. As soon as the ice went out of the river observations were discontinued, not to be resumed until the end of the open season about the middle of September. The observing stations, with their geographical coordinates, are given below: The names of the stations are those now in use, with the following exceptions—Nuklukayet is given on the most recent Coast Survey map of Alaska as "Tuklukyet." The post is but a few miles below the junction of the Yukon and Tanana rivers; indeed, it is not certain but that observations were made at the mouth of the Tanana for a portion of the time. Tchatowklin was known in 1883 as Johnny's Village or Klat-ol-Klin (Schwatka). The Coast Survey map gives the name as "Belle Isle." Camp Colonna, the station on the Porcupine River at its intersection with the one hundred and forty-first meridian, was occupied by the boundary survey party sent out by the United States Coast and Geodetic Survey, under the leadership of Mr. J. H. Turner. Camp Davidson is the station at the intersection of the one hundred and forty-first meridian and the Yukon. It was occupied by a Coast Survey party under the charge of Mr. J. E. McGrath.

*Monthly and annual mean temperature (in degrees Fahrenheit).*

MEAN TEMPERATURE.

| Stations. | Latitude. | Longitude. | Elevation. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. | Length of record. From— | To— | Yrs. | Mos. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Coast.* | ° ′ | ° ′ | *Feet.* | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | | | | |
| Fort Wrangell | 56 30 | 132 28 | 25-35 | 26.2 | 30.8 | 31.6 | 42.7 | 49.8 | 55.8 | 58.2 | 57.5 | 52.8 | 45.9 | 33.5 | 32.8 | 43.0 | May, 1868 | Aug., 1882 | 4 | 18 |
| Sitka* | 57 03 | 131 19 | 63 | 31.4 | 32.9 | 35.6 | 40.8 | 47.0 | 52.4 | 55.4 | 55.9 | 51.5 | 44.9 | 38.1 | 33.3 | 43.3 | Jan., 1828 | Dec., 1876 | 45 | 2 |
| Sitka† | | | | 34.2 | 33.0 | 37.2 | 41.9 | 46.9 | 51.6 | 54.4 | 56.6 | 52.3 | 45.7 | 39.8 | 36.0 | 44.5 | April, 1881 | Sept., 1887 | 5 | 18 |
| Killisnoo‡ | 57 22 | 134 29 | | 26.7 | 26.9 | 33.3 | 35.5 | 44.9 | 50.3 | 54.8 | 53.6 | 46.5 | 41.2 | 32.7 | 30.6 | 39.8 | May, 1881 | Dec., 1896 | 11 | 25 |
| Juneau | 58 19 | 134 28 | | 27.5 | 24.7 | 33.5 | 40.1 | 47.7 | 53.6 | 56.6 | 55.0 | 49.9 | 41.9 | 31.2 | 29.3 | 40.9 | May, 1883 | Dec., 1896 | 2 | 28 |
| Kadiak | 57 48 | 152 19 | | 30.0 | 28.2 | 32.6 | 36.3 | 43.2 | 49.5 | 54.7 | 55.2 | 50.0 | 42.3 | 34.7 | 30.5 | 40.6 | Jan., 1869 | Aug., 1896 | 8 | 54 |
| Unalaska* | 53 53 | 166 32 | 13 | 30.0 | 31.9 | 30.4 | 35.6 | 40.9 | 46.3 | 50.6 | 51.9 | 45.5 | 37.6 | 33.6 | 30.1 | 38.7 | Oct., 1827 | April, 1868 | 6 | 20 |
| Unalaska† | 53 54 | 166 24 | 13 | 33.5 | 30.5 | 32.6 | 35.2 | 40.4 | 45.9 | 49.6 | 50.3 | 46.0 | 40.4 | 34.6 | 32.8 | 39.3 | June, 1872 | May, 1886 | 2 | 33 |
| St. Michaels | 63 28 | 161 48 | 30 | 7.4 | − 2.3 | 8.9 | 19.9 | 33.1 | 46.3 | 53.6 | 51.9 | 43.9 | 30.5 | 15.6 | 4.8 | 26.1 | July, 1874 | June, 1886 | 11 | 12 |
| Point Barrow | 71 23 | 156 16 | | −17.5 | −18.6 | −11.8 | − 1.2 | 21.4 | 32.8 | 38.1 | 37.9 | 27.8 | 4.4 | −6.0 | −15.4 | 7.7 | Sept., 1852 | Aug., 1883 | 3 | 10 |
| *Interior.* | | | | | | | | | | | | | | | | | | | | |
| Anvik | 62 37 | 160 08 | | 1.8 | 1.3 | 15.5 | 25.4 | 42.0 | | | | 43.0 | 25.1 | 10.0 | − 2.1 | | Oct., 1882 | Mar., 1891 | | 31 |
| Nuklukayet | 65 10 | 152 45 | | −11.1 | − 9.0 | 6.7 | 22.2 | 43.7 | | | 54.4 | 43.4 | 25.9 | −4.6 | −19.9 | | Aug., 1882 | May, 1886 | | 27 |
| Fort Yukon | 66 33 | 145 18 | 412 | −29.5 | −11.6 | 0.6 | | 41.3 | | | | | | | | | Jan., 1861 | May, 1861 | | 4 |
| Tchatowklin | 65 30 | 142 38 | | −15.8 | −11.8 | 11.3 | 31.0 | 45.1 | | | 54.2 | 42.7 | 19.7 | 2.5 | −15.0 | | Oct., 1882 | May, 1886 | | 26 |
| Fort Reliance | 64 10 | 139 25 | | −28.7 | −19.7 | 10.5 | 28.7 | 43.9 | | | | 43.9 | 27.3 | −7.0 | −21.4 | | Sept., 1882 | May, 1886 | | 16 |
| Camp Davidson | | | | −17.4 | − 9.9 | 7.1 | 23.6 | 45.0 | 57.2 | 60.3 | 52.1 | 39.0 | 30.5 | 2.9 | −15.6 | 22.9 | Sept., 1889 | June, 1891 | 1 | 10 |
| Camp Colonna | | | | −15.2 | −15.3 | − 8.0 | 6.4 | 41.0 | 51.9 | | | | 20.1 | −4.4 | −17.4 | | Oct., 1889 | June, 1890 | | 9 |

EXTREMES OF TEMPERATURE—MAXIMUM.

| Stations. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Anvik | 35 | 37 | 46 | 46 | 67 | | | 65 | 66 | 51 | 39 | 25 |
| Nuklukayet | 35 | 38 | 46 | 52 | 72 | | | 79 | 72 | 54 | 36 | 17 |
| Tchatowklin | 17 | 33 | 56 | 62 | 82 | | | 80 | 78 | 59 | 39 | 39 |
| Fort Reliance | 20 | 27 | 45 | 59 | 76 | | | | 67 | 55 | 36 | 34 |
| Camp Davidson | 25 | 37 | 38 | 56 | 74 | 84 | 87 | 74 | 66 | 52 | 39 | 17 |
| Camp Colonna | 17 | 36 | 33 | 51 | 68 | 79 | 85 | | | 34 | 34 | 17 |

EXTREMES OF TEMPERATURE—MINIMUM.

| Stations. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Anvik | | | | | | | | | | | | |
| Nuklukayet | −76 | −60 | −38 | −14 | 11 | | | 28 | 12 | −21 | −53 | −68 |
| Tchatowklin | −75 | −74 | −56 | −11 | 10 | | | 30 | 8 | −28 | −50 | −68 |
| Fort Reliance | −80 | −72 | −36 | −10 | 16 | | | | 18 | −11 | −50 | −69 |
| Camp Davidson | −60 | −55 | −45 | −26 | 8 | 30 | 35 | 31 | 14 | 4 | −35 | −49 |
| Camp Colonna | −49 | −47 | −48 | −28 | 15 | 26 | 36 | | | − 6 | −36 | −43 |

Note.—The number of years during which observations were made continuously is given under the heading "Years." The total number of months, exclusive of the whole years, is given under the heading "Months." * Russian series. † Signal Service. ‡ Means from 1889-1896, inclusive, used; means prior to that time not computed.